IEEE P802.11
Wireless LANs

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| CID3309 ESTTHROUGHPUT SAP enhancements |
| Date: 2014-08-03 |
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|  |  |  |  |  |

Abstract

This document proposes modifications to the ESTTHROUGHPUT SAPs introduced by the resolution of CID 3309 of LB202, specifically, to add a estimate parameter for an estimate of uplink throughput and to include an example algorithm for determining the estimated throughput values.

**REVISION NOTES:**

R0: initial

Interpretation of a Motion to Adopt

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGmc Draft. This introduction is not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TGmc Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

***TGmc Editor: Editing instructions preceded by “Instruction to Editor” are instructions to the TGmc editor to modify existing material in the TGmc draft. As a result of adopting the changes, the TGmc editor will execute the instructions rather than copy them to the TGmc Draft.***

**CID LIST:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 3309 | Matthew Fischer | 143.50 | 6.3 | Sometimes, it is an outside entity that needs to make a decision as to which BSS to choose for association. Those external entities would benefit by knowing the expected throughput of a possible association. Provide a hook for this information to be communicated through the MLME SAP. | Add a SAP called:MLME-ESTTHROUGHPUT.requestwith parameter list:PeerSTAAddresswith a valid range of "Any valid MAC address" and a description of "Specifies the address of the peer MAC entity with which to estimate throughput."Add a SAP called:MLME-ESTTHROUGHPUT.confirmwith parameter list:PeerSTAAddresswith a valid range of "Any valid MAC address" and a description of "Specifies the address of the peer MAC entity with which an estimate of throughput was calculated."Estimated Throughputwith a valid range of "either -1, or a floating point value [0,infinite]"and a description of "Specifies the estimated throughput that is possible between this STA and the peer STA if an association is established." | Revise - generally agree with commenter, TGmc editor to execute proposed changes from 11-14-0792r6 found under all headings which include CID3309 |

**Discussion:**

During the July 2014 session, new SAPs for estimated throughput of an existing or potential connection were described within document 11-14-0792 proposing a resolution for CID 3309. As part of the discussion of that document, two major concerns arose about the general nature of the proposal. The first was the question of directionality of the estimate of throughput and the second question was concerning the accuracy of the estimate and the consistency of estimates across implementations.

The question of uplink vs downlink at the July 2014 session prompted the authors to revise the document in a manner so that only the downlink case was described even though the sentiment of the body suggested a preference for including the uplink case as well; The reason that the uplink case was not included at that session was because of a lack of time to sufficiently prepare and review the text that would have been needed to cover that case; Despite the lack of the presence of material to cover the uplink case, the body chose to proceed with the amended material with the promise from the authors that further refinements would be offered at subsequent meetings.

As to the question of the accuracy of the estimates, while it was argued that no estimate could ever promise to accurately predict all possible future conditions and therefore, a measure of accuracy is in some sense, moot, the discussion did converge on the idea that some generalized algorithm for generating an estimate would be useful because it could allow for some consistency which would in turn allow for reasonably accurate heuristics to be developed by centralized connection managers for use in making decisions about potential WLAN connections and traffic steering.

This document is a positive response to both of those issues, meaning that it attempts to provide a solution to both problems by introducing a significant number of refinements to the original proposal. Specifically, it introduces an element containing a set of parameters that can be exchanged between STAs to assist in determining potential uplink traffic throughput estimates and requires the use of an existing element for a similar purpose, proposing to include both of these elements in certain frames. Secondly, it provides a generalized algorithm which shows a simple method that can be used to combine a large set of parameters to produce an estimated throughput value.

**Proposed changes**

**CID 3309**

***TGmc editor: add an abbreviation to TGmc draft P802.11REVmcD3.0 as shown:***

**3.x Abbreviations**

ESP Estimated Service Parameters

***TGmc editor: modify the Estimated Throughput (ESTT) SAP subclauses as shown, noting that the subclause numbering is estimated and that the editor shall use the correct subclause numbering as appropriate:***

**6.3.102a Estimated Throughput (EST)**

**6.3.102a.1 General**

The following set of MLME primitives support the transport of an estimate of the throughput for a potential or existing association between the STA and an another STA.

**6.3.102a.2 MLME-ESTIMATED-THROUGHPUT.request**

**6.3.102a.2.1 Function**

This primitive is generated by the SME to request that the MLME provide an estimated throughput for a potential or existing association.

**6.3.102a.2.2 Semantics of the service primitive**

The primitive parameters are as follows:

MLME-ESTIMATED-THROUGHPUT.request(

 PeerMACAddress,

 AverageMSDUSizeDownlink,

 AverageMSDUSizeUplink

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| PeerMACAddress | MACAddress | Any valid individual MAC address | Specifies the MAC address of the STA for which throughput is to be estimated assuming an association to that STA if an association with that STA does not currently exist. |
| AverageMSDUSizeDownlink | Set of Integers | -1 - 7920 (for each integer in the set) | A set of integers providing an estimate of the average number of octets per MSDU expected to be delivered to the wireless medium by the STA corresponding to the PeerMACAddress to this STA, specified per access category. A value of 0 means that the size is unspecified, a value of -1 means that no MSDUs are expected to be delivered for this access category. |
| AverageMSDUSizeUplink | Set of Integers | -1 - 7920 (for each integer in the set) | A set of integers providing an estimate of the average number of octets per MSDU expected to be delivered to the wireless medium by this STA to the STA corresponding to the PeerMACAddress, specified per access category. A value of 0 means that the size is unspecified, a value of -1 means that no MSDUs are expected to be delivered for this access category. |

**6.3.102a.2.3 When generated**

This primitive is generated by the SME to request that the MLME provide an estimate of throughput for MSDUs sent between this STA and the STA which corresponds to the PeerMACAddress provided in the parameter list.

**6.3.102a.2.4 Effect of receipt**

On receipt of this primitive, the MLME generates a set of estimates of throughput for MSDUs sent between the STA which corresponds to the PeerMACAddress provided in the parameter list and this STA.

**6.3.102a.3 MLME-ESTIMATED-THROUGHPUT.confirm**

**6.3.102a.3.1 Function**

This primitive reports the result of a request to provide a set of estimated throughput values for a potential or existing association.

**6.3.102a.3.2 Semantics of the service primitive**

The primitive uses the following parameters:

MLME-ESTIMATED-THROUGHPUT.confirm(

 PeerMACAddress,

 EstimatedThroughputDownlink,

 EstimatedThroughputUplink

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| PeerMACAddress | MACAddress | Any valid individual MAC address | Specifies the MAC address of the STA for which throughput is to be estimated assuming an association to that STA if an association with that STA does not currently exist. |
| EstimatedThroughputDownlink | A set of Real Numbers | Non-negative real numbers. | The estimated throughput in the direction from the STA corresponding to the PeerMACAddress to this STA with units of bits per second, specified per access category. A value of 0 means no estimate is available. |
| EstimatedThroughputUplink | A set of Real Numbers | Non-negative real numbers. | The estimated throughput in the direction from this STA to the STA corresponding to the PeerMACAddress with units of bits per second, specified per access category. A value of 0 means no estimate is available. |

**6.3.102a.3.3 When generated**

This primitive is generated by the MLME to provide a set of estimates of throughput for MSDUs sent between the STA which corresponds to the PeerMACAddress indicated in the parameter list and this STA.

**6.3.102a.3.4 Effect of receipt**

On receipt of this primitive, the SME may use the reported estimates to make association and forwarding decisions.

***TGmc editor: modify the Estimated throughput subclause as shown:***

**10.44a Estimated throughput**

A STA that has a value of true for dot11EstimatedServiceParametersOptionImplemented is an ESP STA.

Many external entities wishing to control the traffic steering decision of a device will benefit by being able to predict the throughput that can be obtained through an association with a peer STA. Those same entities also need to know what the current expectation for throughput is for network selection purposes. The MLME-ESTIMATED-THROUGHPUT.request and MLME-ESTIMATED-THROUGHPUT.confirm SAPs together provide an interface to allow such external entities, operating through the SME, to obtain an estimate of throughput for MSDUs sent between the STA which corresponds to the PeerMACAddress indicated in the parameter list of the MLME-ESTIMATED-THROUGHPUT.request and this STA.

When an MLME-ESTIMATED-THROUGHPUT.request is received at the MLME, the MLME can use the parameters provided in the SAP plus the following information to create estimates of throughput per access category to deliver to the SME in the EstimatedThroughputDownlink parameter of the MLME-ESTIMATED-THROUGHPUT.confirm:

* Averaged RSSI measured during receptions of PPDUs transmitted by the STA that corresponds to the MAC entity with the MAC address equal to the PeerMACAddress in the MLME-ESTIMATED-THROUGHPUT.request to this STA
* Number of spatial streams that is expected to be supported on the link between this STA and the peer STA
* Channel bandwidth
* BSS Load information known by this STA or obtained from the peer STA
* Block Ack Window size

An ESP STA should generate an estimated MCS (PHY datarate) based on the first three parameters listed above. The PHY datarate may be scaled, for example, by the BSS Load parameter and an overhead esimtate to determine the set of values for the EstimatedTthroughputDownlink parameter.

When an MLME-ESTIMATED-THROUGHPUT.request is received at the MLME, the MLME should use the parameters provided in the SAP plus the following information to create estimates of throughput per access category to deliver to the SME in the EstimatedThroughputUplink parameter of the MLME-ESTIMATED-THROUGHPUT.confirm:

* Averaged RSSI measured during receptions of PPDUs transmitted by this STA to the STA that corresponds to the MAC entity with the MAC address equal to the PeerMACAddress in the MLME-ESTIMATED-THROUGHPUT.request
* Number of spatial streams that is expected to be supported on the link between this STA and the peer STA
* Channel bandwidth
* BSS Load information known by this STA or obtained from the peer STA
* Block Ack Window size

An ESP STA should generate an estimated MCS (PHY datarate) based on the first three parameters listed above. The PHY datarate may be scaled, for example, by the BSS Load parameter and an overhead esimtate to determine the set of values for the EstimatedTthroughputUplink parameter.

The following additional parameters may be used to refine the throughput estimates:

* Channel Utilization
* Number of associations at the peer STA if the peer STA is an AP
* QoS admissions at the peer STA if the peer STA is an AP
* Available admission capacity at the peer STA if the peer STA is an AP
* STA AMSDU QoS admissions at the peer STA if the peer STA is an AP
* Power Save operation mode and parameters

If the MLME is incapable of determining a value for the EstimatedThroughputDownlink or EstimatedThroughputUplink parameter for any access category, then the MLME shall return the value of 0 for the value of that parameter for that access category in the MLME-ESTIMATED-THROUGHPUT.confirm primitive. If the AverageMSDUSizeDownlink parameter for an access category is equal to -1 in the MLME-ESTIMATED-THROUGHPUT.request, the STA shall include a value of 0 in the EstimatedThroughputDownlink parameter for the corresponding access category in the MLME-ESTIMATED-THROUGHPUT.confirm. If the AverageMSDUSizeDownlink parameter for an access category is equal to 0 in the MLME-ESTIMATED-THROUGHPUT.request, the STA may assume any value for the average MSDU size used in calculating the estimated throughput to be included in the corresponding access category in the EstimatedThroughputDownlink parameter of the MLME-ESTIMATED-THROUGHPUT.confirm, but should use a value of 1500 octets. If the AverageMSDUSizeUplink parameter for an access category is equal to -1 in the MLME-ESTIMATED-THROUGHPUT.request, the STA shall include a value of 0 in the EstimatedThroughputUplink parameter for the corresponding access category in the MLME-ESTIMATED-THROUGHPUT.confirm. If the AverageMSDUSizeUplink parameter for an access category is equal to 0 in the MLME-ESTIMATED-THROUGHPUT.request, the STA may assume any value for the average MSDU size used in calculating the estimated throughput to be included in the corresponding access category in the EstimatedThroughputUplink parameter of the MLME-ESTIMATED-THROUGHPUT.confirm, but should use a value of 1500 octets.

ESP STAs should determine values for EstimatedThroughputDownlink and EstimatedThroughputUplink for each AC of a current or potential link to another STA using the equation found in V.7 (Calculating EstimatedThroughput).

An ESP STA shall include a Request element that includes the ESP element ID and the RSSI element ID in transmitted Probe Requests.

An ESP STA shall include the ESP element within Probe Request frames.

An ESP STA shall include the ESP element within Probe Response frames transmitted to an ESP STA. An ESP STA shall include the RSSI element within Probe Response frames transmitted to an ESP STA with the value of the RSSI field based on receptions of PPDUs received from the ESP STA that is the intended recipient of the probe response. An ESP STA may include the ESP element within Probe Response frames transmitted to STAs that are not ESP STAs. An ESP STA may include the RSSI element within Probe Response frames transmitted to STAs that are not ESP STAs and shall set the value of the RSSI field based on receptions of PPDUs received from the STA that is the intended recipient of the probe response.

An ESP STA shall include the ESP element within Beacon frames.

***TGmc editor: add one row to the table of Beacon frame body components, Table 8-35 Beacon frame body, as shown:***

**8.3.3.2 Beacon frame format**

**Table 8-35—Beacon frame body**

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| <ANA> | Estimated Service Parameters | The Estimated Service Parameters element is present if dot11EstimatedServiceParametersOptionImplemented is true. |

***TGmc editor: add two rows to the table of Probe Request frame body components, Table 8-41 Probe Request frame body, as shown:***

**8.3.3.9 Probe Request frame format**

**Table 8-41—Probe Request frame body**

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| <ANA> | Estimated Service Parameters | The Estimated Service Parameters element is present if dot11EstimatedServiceParametersOptionImplemented is true. |
| <ANA> | RSSI | The RSSI element is present if dot11EstimatedServiceParametersOptionImplemented is true. |

***TGmc editor: modify the row with value 3 in the order column in the table of Probe Request frame body components, Table 8-41 Probe Request frame body, as shown:***

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| 3 | Request information | The Request element is optionally present if dot11MultiDomainCapabilityActivated is true and is present if dot11EstimatedServiceParametersOptionImplemented is true. |

***TGmc editor: add two rows to the table of Probe Request frame body components, Table 8-41 Probe Request frame body, as shown:***

**8.3.3.10 Probe Response frame format**

**Table 8-42—Probe Response frame body**

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| <ANA> | Estimated Service Parameters | The Estimated Service Parameters element is optionally present if dot11EstimatedServiceParametersOptionImplemented is true. |
| <ANA> | RSSI | The RSSI element is present if dot11EstimatedServiceParametersOptionImplemented is true. |

***TGmc editor: modify the row with value “Last” in the order column in the table of Probe Response frame body components, Table 8-42 Probe Response frame body, as shown:***

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| Last | Requested elements | Elements requested by the Request element of the Probe Request frame are present if dot11MultiDomainCapabilityActivated or dot11EstimatedServiceParametersOptionImplemented is true. See 10.1.4.3.2 (Active scanning procedure for a non-DMG STA) and 10.44a (Estimated throughput). |

***TGmc editor: add two rows to the table of elements, Table 8-85 Element IDs as shown:***

**8.4.2.1 General**

**Table 8-85—Element IDs**

|  |  |  |
| --- | --- | --- |
| Element | Element ID | Extensible |
| Estimated service parameters (see 8.4.2.170m Estimated service parameters element) | <ANA> | Yes |
| RSSI (see 8.4.2.170n RSSI element) | <ANA> | Yes |

***TGmc editor: add the following new element with appropriate subclause numbering:***

**8.4.2.170m Estimated service parameters (ESP) element**

The Estimated Service Parameters element is used by a STA to provide information to another STA which can then use the information as input to an algorithm to generate an estimate of throughput between the two STAs.

The format of the Estimated Service Parameters element is shown in Figure 8-mmm (Estimated service parameters element format). The value of N in the diagram corresponds to the number of Access Categories for which Estimated Service Parameters information is provided and has a value from 1 to 4.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Element ID | Length | ESP Information |
| Octets: | 1 | 1 | N x 2 |

**Figure 8-mmm Estimated Service Parameters element format**

The Element ID and Length fields are defined in 8.4.2.1 (General).

The format of the ESP Information field is shown in Figure 8-mma (ESP Information field format).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | B15 B14 | B13 | B12 B11 | B10 B8 | B7 B0 |
|  | Access Category | RTS Use | Data Format | BA Window Size | Data PPDU Duration Target |
| Bits: | 2 | 1 | 2 | 3 | 8 |

**Figure 8-mma ESP Information field format**

The Access Category subfield is two bits in length and indicates the Access Category to which the remaining parameters of the ESP Information field apply.The encoding of the Access Category field is given in Table 8-vvv Access Category subfield encoding. When parameters for more than one Access Category are present in an ESP element the ESP Information fields for the Access Categories appear in order of Access Category subfield value, with the ESP Information field with the lowest Access Category subfield value appearing first.

**Table 8-vvv Access Category subfield encoding**

|  |  |
| --- | --- |
| Value | Access Category |
| 00b | AC\_BK |
| 01b | AC\_BE |
| 10b | AC\_VI |
| 11b | AC\_VO |

The RTS Use subfield is set to 1 to indicate that an RTS/CTS exchange is expected to be included at the start of each TXOP initiated for the corresponding access category by the STA that has transmitted the ESP Information element.

The Data format subfield is two bits in length and has the meaning indicated in Table 8-www (Data format subfield encoding).

**Table 8-www Data format subfield encoding**

|  |  |  |
| --- | --- | --- |
| Value | Name | Description |
| 00b | NoAgg | No aggregation is expected to be perfomed for MSDUs or MPDUs of Type DATA for the corresponding AC |
| 01b | AMSDUAgg | AMSDU aggregation is expected to be perfomed for MSDUs for the corresponding AC, but AMPDU aggregation is not expected to be performed for MPDUs of Type DATA for the corresponding AC |
| 10b | AMPDUAgg | AMPDU aggregation is expected to be perfomed for MPDUs of Type DATA for the corresponding AC, but AMSDU aggregation is not expected to be performed for MSDUs for the corresponding AC |
| 11b | CombinedAgg | AMSDU aggregation is expected to be perfomed for MSDUs for the corresponding AC and AMPDU aggregation is expected to be performed for MPDUs of Type DATA for the corresponding AC |

The BA Window Size subfield is three bits in length and indicates the size of the Block Ack window that is expected for the corresponding Access Category as per the encoding indicated in Table 8-yyy (BA Window Size subfield encoding). When the Block Ack window size expected to be used by the transmitter of the element does not match any of the values shown in the table, the transmitter uses the next lower value in the table.

**Table 8-yyy BA Window Size subfield encoding**

|  |  |
| --- | --- |
| Value | Expected BA Window Size |
| 000b | Block Ack not expected to be used |
| 001b | 2 |
| 010b | 4 |
| 011b | 6 |
| 100b | 8 |
| 101b | 16 |
| 110b | 32 |
| 111b | 64 |

The DATA PPDU Duration Target field is 8 bits in length and is an unsigned integer that indicates the expected target duration of PPDUs that contain at least one MPDU of Type DATA for the corresponding Access Category where the least significant bit of the integer corresponds to 50 usec.

***TGmc editor: add the following new element with appropriate subclause numbering:***

**8.4.2.170n RSSI element**

The RSSI element indicates the received frame power level at the receiving STA as shown in Figure 8-nna (RSSI element format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Element ID | Length | RSSI |
| Octets: | 1 | 1 | 1 |

**Figure 8-nna - RSSI element format**

The RSSI field contains an RSSI value as specified for certain PHYs in Clause 16 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications), Clause 18 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 17 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 19 (Extended Rate PHY (ERP) specification), Clause 20 (High Throughput (HT) PHY specification) and Clause 22 (Very High Throughput (VHT) PHY specification). A value of 255 means that no RSSI value is available.

***TGmc editor: add the following new MIB variable to the dot11StationConfig group:***

**C.3 MIB Detail**

dot11EstimatedServiceParametersOptionImplemented OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This is a capability variable.

Its value is determined by device capabilities.

This attribute, when true, indicates that the IEEE 802.11 Estimated Service Parameters option is implemented."

DEFVAL { false }

::= { dot11StationConfigEntry <ANA> }

***TGmc editor: add the following new subclause to Annex V:***

**V.7 Calculating EstimatedThroughput**

In response to the receipt of MLME-ESTIMATED-THROUGHPUT.request, ESP STAs can determine values for EstimatedThroughputDownlink and EstimatedThroughputUplink for each AC of a current or potential link to another STA using equation V.7-aaa:

Equation V.7-aaa:

EstimatedThroughput = (MPDU\_pPPDU x AMSDU\_B x 8) / (BOV + RCOV + PPDU\_DUR) \* EST\_AIRTIME\_FRACTION

Where,

MPDU\_pPPDU = MIN(BA\_WIN\_SIZE, MAX(1,MPDU\_pAMPDU))

MIN(x,y) = the minimum of x and y

MAX(x,y) = the maximum of x and y

BA\_WIN\_SIZE = MIN(BA\_WIN\_SIZE\_TX, BA\_WIN\_SIZE\_RX)

BA\_WIN\_SIZE\_TX = the expected BA window size of the transmitter of the PPDUs containing Data Type MPDUs

BA\_WIN\_SIZE\_RX = the expected BA window size of the receiver of the PPDUs containing Data Type MPDUs

MPDU\_pAMPDU = MIN(FLOOR(PPDUR/MPDU\_SS),FLOOR(PPDUR/((50+AMSDU\_B)\*8))))

FLOOR(R) = the greatest integer that has a value less than or equal to the number R

PPDUR = DPDUR - PHDUR

DPDUR = Data PPDU Duration Target of the transmitter of the PPDUs containing Data Type MPDUs

PHDUR = PHY Header Duration, estimated based on the expected PPDU format of the PPDUs containing Data Type MPDUs

MPDU\_SS = the Minimum MPDU Start Spacing of the receiver of the PPDUs containing Data Type MPDUs

AMSDU\_B = MIN(AMSDU\_B\_TX, AMSDU\_B\_RX)

AMSDU\_B\_TX = the maximum AMSDU size of the transmitter of the PPDUs containing Data Type MPDUs

AMSDU\_B\_RX = the maximum AMSDU size of the receiver of the PPDUs containing Data Type MPDUs

BOV = CWMIN[AC] / 2 \* SLOT

RCOV = RTS\_DUR + CTS\_DUR + 2 x SIFS

RTS\_DUR = the expected duration of an RTS frame sent at the BSS Basic Rate or MCS VHT-MCS (whichever is applicable) that is determined as the control response rate assuming an eliciting frame rate equal to the value of DataRate calculated in equation V.7-ccc

CTS\_DUR = the expected duration of a CTS frame sent at the BSS Basic Rate or MCS VHT-MCS (whichever is applicable) that is determined as the control response rate assuming an eliciting frame rate equal to the value of DataRate calculated in equation V.7-ccc

PPDU\_DUR = CEIL((50+AMSDU\_B)\*MPDU\_pPPDU\*8 / DataRate / DSYM\_DUR) \* DSYM\_DUR

DSYM\_DUR = the duration of one PPDU Payload symbol for the expected PHY format of the PPDUs containing Data Type MPDUs

DataRate is calculated using one of equations V.7-bbb through V.7-eee.

EST\_AIRTIME\_FRACTION = the estimated portion of airtime that is available for transmissions for this link

Note that some of the parameters of the equation have values which are AC dependent.

If an ESP STA expects that an HR/DSSS rate or ERP rate or OFDM rate will be used for the transmission of the PPDUs which contain Data Type MPDUs on the link, the STA should use equation V.7-bbb to calculate the estimated throughput of the link. If the STA expects that an HT MCS will be used for the transmission of the PPDUs which contain Data Type MPDUs on the link, the STA should use equation V.7-ccc to calculate the estimated throughput of the link. If the STA expects that a VHT MCS will be used for the transmission of the PPDUs which contain Data Type MPDUs on the link, the STA should use equation V.7-ddd to calculate the estimated throughput of the link. If the STA expects that a TVHT MCS will be used for the transmission of the PPDUs which contain Data Type MPDUs on the link, the STA should use equation V.7-eee to calculate the estimated throughput of the link. Each of the parameters in the equations corresponds to the parameters expected to be applied by the transmitter of the PPDUs in the link which contain Data Type MPDUs except for the RSSI parameter which is measured at the receiver side of the link during receptions from the transmitter. Noise is measured at the STA calculating the estimated throughput value for both downlink and uplink estimates.

Equation V.7-bbb:

DataRate = DR(RSSI - Noise)

Where,

DR(*x*) = the bit rate that yields 10% PER for PPDUs with a PHY payload of 1000 octets in an AWGN channel at the frequency which the link will operate given an SINR of *x* dB using the PER SNR curves shown in Figure V.7-zzz Estimated Throughput AWGN SNR PER Curves.

Noise = measured or estimated noise in the channel in which the link will operate

Equation V.7-ccc:

DataRate = DataRateHT(MCS(RSSI - Noise), NSS, NES, GI, BW)

Where,

MCS(*x*) = the MCS that yields 10% PER for PPDUs with a payload of 1000 octets in an AWGN channel at the frequency which the link will operate given an SINR of *x* dB

RSSI = the RSSI measured at the receiver of the PPDUs containing Data Type MPDUs of a frame transmitted by the transmitter of the PPDUs

Nss = the number of spatial streams expected to be employed for PPDUs containing Data Type MPDUs

Noise = measured or estimated noise in the channel in which the link will operate

DataRateHT(*mcs,nss,nes,gi*) = the Data Rate indicated in the appropriate table of subclause 20.5 (Parameters for HT MCSs) for an MCS of *mcs*, NSS of *nss*, NES of *nes* and guard interval of *gi*, where *gi* can have one of the two values 800ns or 400ns.

BW = the expected bandwidth of the PPDUs containing Data Type MPDUs

If the expected value of NES is not known, then the STA shall use the value of 1 for NES.

Equation V.7-ddd:

DataRate = DataRateVHT(VHTMCS(RSSI - Noise), NSS, NES, GI, BW)

Where,

VHTMCS(*x*) = the VHT-MCS that yields 10% PER for PPDUs with a payload of 1000 octets in an AWGN channel at the frequency which the link will operate given an SINR of *x* dB

RSSI = the RSSI measured at the receiver of the PPDUs containing Data Type MPDUs of a frame transmitted by the transmitter of the PPDUs

Nss = the number of spatial streams expected to be employed for PPDUs containing Data Type MPDUs

Noise = measured or estimated noise in the channel in which the link will operate

DataRateVHT(*mcs,nss,nes,gi*) = the Data Rate indicated in the appropriate table of subclause 22.5 (Parameters for VHT-MCSs) for a VHT-MCS of *mcs*, NSS of *nss*, NES of *nes* and guard interval of *gi*, where *gi* can have one of the two values 800ns or 400ns.

BW = the expected bandwidth of the PPDUs containing Data Type MPDUs

If the expected value of NES is not known, then the STA shall use the value of 1 for NES.

Equation V.7-eee:

DataRate = DataRateTVHT(TVHTMCS(RSSI - Noise), NSS, NES, GI, BW)

Where,

TVHTMCS(*x*) = the TVHT-MCS that yields 10% PER for PPDUs with a payload of 1000 octets in an AWGN channel at the frequency which the link will operate given an SINR of *x* dB

RSSI = the RSSI measured at the receiver of the PPDUs containing Data Type MPDUs of a frame transmitted by the transmitter of the PPDUs

Nss = the number of spatial streams expected to be employed for PPDUs containing Data Type MPDUs

Noise = measured or estimated noise in the channel in which the link will operate

DataRateTVHT(*mcs,nss,nes,gi*) = the Data Rate indicated in the appropriate table of subclause 22.5 (Parameters for TVHT-MCSs) for a TVHT-MCS of *mcs*, NSS of *nss*, NES of *nes* and guard interval of *gi*, where *gi* can have one of the two values 800ns or 400ns.

BW = the expected bandwidth of the PPDUs containing Data Type MPDUs

If the expected value of NES is not known, then the STA uses the value of 1 for NES.

If no RSSI value has been received from the receiver of the PPDUs containing Data Type MPDUs, the ESP STA calculating an estimated throughput uses the averaged RSSI value of all of the frames received from the receiver in the previous 1 second, or the RSSI of the most recently received frame from the receiver if there have been no receptions from the receiver in the last 1 second. If no frames have been received from the receiver in the previous 10 seconds, then the STA uses the value 0 for the estimated throughput, meaning that no estimate is available.

***TGmc editor: insert a new figure with caption “Figure V.7-zzz Estimated Throughput AWGN SNR PER curves” and showing a family of curves as follows:***

1. ***The y-axis showing a log scale of PER (1000 Byte PHY Payload) with the value 1 at the top and the value 0.001 at the bottom***
2. ***The x-axis showing a linear scale of SNR (dB) with -10 at the left and +40 on the right***
3. ***A set of curves, each of which has a unique label from MCS0 through MCS9, with the following points lying on each line: (3,0.1) for MCS0, (7,0.1) for MCS1, (9.5,0.1) for MCS2, (12.5,0.1) for MCS3, (16,0.1) MCS4, (21,0.1) for MCS5, (23,0.1) for MCS6, (24.5,0.1) for MCS7, (28,0.1) for MCS8, (30,0.1) for MCS9***
4. ***Each curve’s y-axis value is limited to maximum value of “1” and each curve has a slope of -0.5 decade on the log scale per +1 dB increase on the x-axis (i.e. a slope of -0.5)***

**References:**